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## ABSTRACT

**Background:** Acute Mountain Sickness (AMS) is a common complaint of trekkers to high altitude. The UK Military train at high altitude through adventurous training (AT) or as exercising troops. The ascent of Point Lenana, 4985m, on Mount Kenya, is frequently attempted on AT. We sought to establish the incidence of AMS within this population, to aid future planning for military activities at altitude.

**Methods:** A voluntary questionnaire was distributed to all British Army Training Unit Kenya (BATUK) based expeditions attempting to ascend Mount Kenya during the period February to April 2014. The questionnaire included twice daily Lake Louise and Borg (perceived exertion scale) self-scoring. All expeditions were planned around a 5 day schedule, which included reserve time for acclimatisation, illness and inclement weather.

**Results:** Data was collected on 47 participants. 70% reached the summit of Point Lenana. 62% (29/47) self reported AMS (defined as Lake Louise score (LLS)  $\geq 3$ ) on at least one occasion during the ascent, of these 34% (10/29) suffered severe AMS (LLS  $\geq 6$ ). Those who attempted the climb within 2 weeks of arrival in Kenya had a higher incidence of AMS, 12/15 (80%) vs. 17/32 (53%) ( $p=0.077$ ). Participants recording a High Borg Score were significantly more likely to develop AMS (16/18 vs. 9/21) ( $p=0.003$ ).

**Conclusion:** We present the first informative data-set for Mount Kenya ascents and altitude. The incidence of AMS during AT on Mount Kenya using this ascent profile is high. Adapting the current ascent profile, planning the ascent after time in country and reducing perceived exertion during the trek may reduce the incidence of AMS.

## INTRODUCTION

Trekking to altitude has become an increasingly popular pastime, putting increasing numbers of the general population at risk of altitude related illness or injury. Altitude exposure is also militarily important, with many of the world's worst hit conflict zones being in areas of mountainous terrain. Pakistani troops have been in Kashmir for over 50 years, and there are permanent manned outposts for both Indian and Pakistani troops at over 5000m altitude. The Kargil Conflict that erupted in 1999, saw the highest documented warfare in recent history, and it was only with use of seasoned and acclimatised troops that fighting was able to take place (1,2). The 1<sup>st</sup> and 2<sup>nd</sup> World Wars included fighting at altitude within Alpine terrain – with both German and US forces developing specialised mountain units and the UK establishing a Mountain Warfare Training Centre at moderate altitude in the Lebanon during the 2<sup>nd</sup> World War. Most recently the Afghanistan conflict has involved coalition troops fighting at altitude. Operation ANACONDA in 2002 is the highest recorded US Force operation at altitude – with approximately 1500 troops deployed to altitudes between 2400-3600m for 11 days. Prophylactic acetazolamide was used 24 hours prior to deployment in some un-acclimatised troops (3), however 12% of casualties treated by the Forward Surgical Team were as a result of altitude illness (4). With the return to contingency operations military forces need to be prepared to fight in a variety of environments, including high altitude.

Mount Kenya has 3 summits, with the third highest – Point Lenana (4985m) the highest point reached with no technical climbing required. This location is often chosen for adventurous training (AT) during a Unit's operational training in Kenya. The summit lies at Very High Altitude, defined as being within 3500m – 5800m. At this elevation altitude illness is common, and an oxygen saturation (SpO<sub>2</sub>) <90% is typical with more marked hypoxaemia expected during exercise (5). Altitude illness consists of Acute Mountain Sickness (AMS), High Altitude Cerebral Oedema (HACE) and High Altitude Pulmonary Oedema (HAPE). AMS is the most common manifestation of High Altitude Illness and consists of a collection of symptoms including headache with nausea, anorexia and lethargy. AMS is a clinical diagnosis that can be graded by the Lake Louise score (6). HAPE and HACE are both potentially fatal conditions.

There are no established data for AMS rates on Mt Kenya. Worldwide AMS rates vary considerably, and are influenced by rate of ascent, individual factors and acclimatisation to altitude (5). Data from Mount Kilimanjaro (5895m), Tanzania, demonstrate high rates of AMS, ranging from 41 to 86%, with Meyer describing a further 14% suffering HACE (7,8).

Mt Kenya and Kilimanjaro share similar climate and ascent profiles, and AMS rates on Mt Kenya could be expected to be similarly high. There is no currently published data from Mount Kenya. We aimed to collect data prospectively on military teams climbing Mt Kenya in order to better inform future AT, ascent rate and safety planning.

Perceived exertion has recently been associated with higher AMS scores and higher levels of stress hormones (9,10). We therefore sought to establish data on the perceived exertion experienced during the trek and whether or not this was associated with AMS.

## METHODS

We undertook an observational data collection approved by the Royal Centre for Defence Medicine (Audit No. RCDM/Res/Audit/1036/14/0395) to assess the impact of AMS on UK Military Soldiers trekking to Point Lenana, Mount Kenya.

Military expeditions attempting to ascend to Point Lenana (4985m) between February and April 2014 were approached to participate in a questionnaire based study to investigate the incidence of AMS in the UK military population when undertaking AT from BATUK.

A total of 7 expeditions attempted to summit Point Lenana during this period. All attempts were via the Sirimon route and were designed as a 5 day expedition (to include both ascent and descent).

All participants of these expeditions undertook a medical brief prior to ascent and were deemed fit to attempt the climb by their Medical Officer. Following the medical brief participants were informed of the data collection and all participants voluntarily recorded their own data during the expedition.

**Questionnaire data:** In brief the data collected included demographic data, PFT data, previous altitude exposure and AMS prior to expedition departure. During the climb twice daily recording of AMS symptoms and Borg Score were performed. Additional information regarding treatment and early descent were also recorded.

**AMS scores:** AMS scores were assessed using the Lake Louise score (LLS). The LLS is a self-assessment questionnaire that allocates a score of 0 to 3 (symptom not present to severe) for symptoms of AMS (headache, gastrointestinal symptoms, fatigue/weakness, dizzy/light-headedness, difficulty sleeping). The maximum score possible is 15, with a score of 3 or more in the presence of headache consistent with AMS (11) and a score of 6 or more in the presence of headache consistent with severe AMS.

**Perceived Exertion :** The Borg Rating of Perceived Exertion (RPE) was recorded at the end of each day to record the hardest perceived exertion experienced during the day. This is a 15 point scale from 6 – 20, with values of 6 representing the resting state and 20, exhaustive exercise. As the European Society of Cardiology recommend exercising at a perceived exertion of 12- 14, a value of 15 or greater was taken as the cut off for a high Borg score (12). An RPE of 15 or greater is perceived as “hard exertion” by the subject, relates to a heart rate of around 150 bpm at sea level and is the level at which anaerobic metabolism starts to become a significant part of energy generation.

**Statistical analysis:** For statistical calculations the software package SPSS 21.0 was used. Parametric or non-parametric statistical tests were applied after performing the Kolmogorov-Smirnov statistic. For independent variables an independent-samples t test or Mann Whitney test was used. For relationships between categorical variables a Chi-square test was used. Significance was assumed at the p=0.05 level.

## RESULTS

Within 7 trekking groups, there was a total of 47 participants (2 females, 45 males), mean age 27 years (range 18 – 57) (Table 1). All persons were taking anti-malarial medication (doxycycline, mefloquine, atovaquone & proguanil), and no one was taking prophylactic altitude medications. While alcohol was not banned prior to departure, it was generally advised against for the preceding few days. During the expedition no alcohol was consumed until return to the camp at 3300m and on the descent only.

**Table 1: Demographics**

|   | <b>Total<br/>(n = 47)</b> |
|---|---------------------------|
| <b>Age, yr mean (range, SD)</b>                         | 27 (18 – 57, 7)           |
| <b>Smokers (n)</b>                                      | 15                        |
| <b>No previous altitude experience (n)</b>              | 29                        |
| <b>Previous altitude experience (n)</b>                 | 18                        |
| <b>Anti-malarial Prophylaxis (n)</b>                    | 47                        |
| <b>Chronic Disease requiring regular medication (n)</b> | 3                         |

All groups attempted to summit from an altitude of 4200m at Shipton's Camp (see expedition altitude profile, table 2, figure 1), of these, 2 groups were not successful due to weather and remits of leader qualifications (12 persons total), and one person did not attempt summit due to symptoms of AMS, with one person remaining with them. 33 persons (70%) successfully summited, 5 after 2 days on the mountain and 28 after an additional acclimatisation day.

**Table 2: Distance and altitude table for Sirimon Route, Mount Kenya**

|                                  | <b>Day 1</b>                           | <b>Day 2</b> | <b>Day 3</b>             | <b>Day 4</b> | <b>Day 5</b> |
|----------------------------------|--|--------------|--------------------------|--------------|--------------|
| <b>Distance (km)</b>             | 9                                      | 17           |                          | 25           | 9            |
| <b>Sleep altitude: start (m)</b> | 1650                                   | 3300         | 4200                     | 4200         | 3300         |
| <b>Max altitude gained (m)</b>   | 3300                                   | 4200         | 4500                     | 4985         | 3300         |
| <b>Sleep altitude: end (m)</b>   | 3300                                   | 4200         | 4200                     | 3300         | 1650         |
| <b>Altitude gain (m)</b>         | +1650                                  | +900         | +300                     | +785         | 0            |
| <b>Notes</b>                     | Includes drive to Sirimon Gate (2700m) |              | 1 group summited (5 pax) | Summit day   |              |

There was a significant increase in LLS with ascent ( $p < 0.001$ ). Mean LLS were highest on the evening of day 2 (figure 2). Overall 29 of 47 participants (61.7%) reported a LLS consistent with AMS ( $\geq 3$ ) and 10 (34.4%) of these suffered severe AMS (LLS  $\geq 6$ ). The incidence of AMS on Day 1 (1650-3300m) was

0%, 38% on Day 2 (3300-4200m), 26% on Day 3 (acclimatisation trek from 4200m), 28% on Day 4 (4200-4985-3300m, summit day), and 0% on Day 5 (walk out from 3300m) (figure 3).

A higher Borg score on the evening of the trek was associated with a higher LLS. Those with a high Borg score ( $\geq 15$ ) had a mean LLS of 3.6 (2.6, 0-9) vs. 1.5 (1.7, 0-7) ( $p < 0.001$ ). There was also a higher LLS on the following morning when Borg score was high: 3.0 (1.8, 0-7) vs. 1.6 (1.8, 0-7) ( $p = 0.001$ ) (figure 4). A recording of a high Borg score was associated with AMS in 16/18 (89%) cases whereas AMS in those recording a Borg  $< 15$  occurred in 9/21 (43%) ( $p = 0.001$ ). Overall Borg score correlated moderately with LLS both on the evening of a trek (Spearman's  $\rho$  0.513,  $p < 0.001$ ) and on the following morning (Spearman's  $\rho$  0.570,  $p < 0.001$ ).

There was a trend towards higher AMS rates in those who had spent less time in Kenya prior to the ascent. The incidence of AMS in those spending 14 days or more in Kenya was 17/32 (53%) vs. 12/15 (80%) in those who had been in country  $< 14$  days ( $p = 0.077$ ).

There was no association between age and AMS (mean in both groups 27 years  $p = 0.44$ ) or smoking history ( $p = 0.0117$ ). PFT times were available for 33/47 participants. There was no significant difference in AMS rates according to PFT times ( $p = 0.6$ ).

Two groups had medical personnel within the trekking party (1 CMT and 1 GDMO). The AMS rates in these groups were 6/8 (75%) with a CMT and 6/7 (86%) with a GDMO vs. 17/32 (53%) with no medical personnel ( $p = 0.192$ ).

## DISCUSSION

This is the first published data set of AMS Scores from Mount Kenya. Our notable findings include: a significant rate of AMS (62%) and severe AMS (34%); and a higher rate of AMS in those with high Borg Scores. There was also a trend, not significant, to greater rates of AMS in those who had been in Kenya for less than 2 weeks. The Mount Kenya National Park became a UNESCO World Heritage site in 1997, and sees 20,000 visitors each year (13), a significant “at-risk” population. Previously reported AMS rates are 42% at around 3000m in Colorado (14) and 60% at around 4500m in the Swiss Alps (15). The AMS rate we observed is similar, and is in line with the incidence reported on Kilimanjaro, 41-82% (7,8,16-18).

The manifestations of AMS can range from an uncomfortable headache to significant disability. These symptoms can be managed very effectively with simple measures: additional rest; simple analgesia; descent which will also prevent the potential progression to the life threatening condition of HACE. However, Karinen et al (18) comment that many trekkers on Kilimanjaro appear to continue ascending towards the summit despite having symptoms of AMS – they document that 42 subjects (38%) suffering AMS at 2700/3700m continued towards the summit. Of these, 12 subjects had to abandon their summit attempt (18). 34% of our population with AMS reported symptoms consistent with severe AMS, of these 10 subjects all but one summited. ‘Summit fever’ is well documented, and can push people to keep ascending when descent may be in their best interests. It is likely that the rapid descent to a sleeping altitude of 3300 m on the summit day, followed by rapid descent to 1650 m the following day in part mitigates against these subjects becoming incapacitated.

In using the LLS as our measurement we appreciate that its validity as a scoring tool is not robust, and indeed Hall et al 2014 (HALL 2014) have proposed that AMS is distinct clinical syndromes rather than one entity and that headache is not a feature of all. We may see an alternative tool being proposed for further measurement of AMS however to allow us to produce comparative data, LLS is currently our best fit. With small numbers in our study there was no value in attempting to replicate different syndromes to what Hall et al are describing.

The 5 day itinerary required by all military expeditions attempting Mount Kenya allows an additional acclimatisation day which goes some way to reducing altitude related symptoms on the mountain (most commercial expeditions are run on a 4 day itinerary). It may be that this improves decision making on the mountain as well as allowing a recovery period for those more affected by the altitude should it be required. AMS presence is not related to summit success (8,19), however on Kilimanjaro there are high rates (75%) of AMS, and low rates (around 45%) of summit success (18). Two of our expeditions had medical personnel present within the trekking group (medical presence only, no leadership role), all 15 persons within these 2 groups summited, despite 80% (12/15) suffering AMS (half of these with severe AMS scores). The significance of this is not clear, as half of these persons also completed the trek with only 7 days in country, again a determinate that may well of predisposed individuals to AMS.

The Wilderness Medical Society (WMS) have published guidelines for ascent above 3000m to allow for adequate acclimatisation – necessary for the adaptation of the human body to lower air pressures and decreased partial pressures of oxygen (14). It is well proven that rapid ascent is a risk

factor for AMS (5). The current guidance above 3000m is to gain no more than 500m sleeping altitude and have a rest day every 3-4 days of ascent (21). Similar guidance is published by the British Mountaineering Council (BMC), and is readily available to non-medics via the BMC website (22). With the short climbing profile for Mount Kenya it is the former guideline that is most relevant. The 5 day ascent profile that the British military currently adhere to is well outwith these guidelines, after a gain into the 'altitude zone' of 1650m on day 1, it is then followed by an ascent of 900m on day 2, and also an ascent of 785m on day 4. Topography plays a part here, with both Kilimanjaro and Mount Kenya being 'free standing' mountains, with good access roads to shorten the time needed to be spent trekking, providing a more time and cost-effective way of climbing these accessible peaks. A review of commercial UK expeditions found that only 17% expeditions to Kilimanjaro complied with WMS guidelines, in comparison with 92% to Everest Base Camp, and 100% to Aconcagua (20). In reality it is difficult to assess actual rate of ascents between groups. While they may be on the same daily intended itinerary due to fitness or weather groups may take a longer or shorter time to complete the day's aims. Expedition planning needs to take into account the exertion saving that using huts will do, compared with the exertion draining that carrying tentage and associated paraphernalia. Currently for attempting the Sirimon route on Mount Kenya we would advocate an overnight stay at Sirimon gate (2700m) with a short acclimatisation trek on day 1, before continuing to use the Old Moses and Shiptons Camp. Altitude gains day 1-4 would then be: 1050; 600; 900; nil; 785.

Our data reinforces the idea, recently reported by our group, that perceived exertion increases the incidence of AMS (9). This factor is significant for military teams with a young, fit, male population where there is likely to be competition between trekkers. Our data do not allow us to elucidate whether the exertion is perceived at a higher level due to the onset of AMS or harder exertion is a causal factor in AMS.

We also report a greater proportion of AMS in participants that had been in country under 14 days. Whilst this finding did not reach significance we believe it is worthy of considering in AT activities, and is supported by White et al review into the benefits of heat acclimatisation with respect to hypoxia at altitude (WHITE AC 2014). Time in country allows some acclimatisation to altitude (individuals were stationed at either 1650m or 800m above sea level) and also importantly to heat. Temperatures in Kenya are on average 14°C higher than the UK during Feb (23,24), and heat illness can present initially with similar symptoms to AMS. Dehydration can reduce ability to acclimatise to altitude and therefore increase risk of developing AMS, again a secondary consideration of increased temperature.

In current literature the only published altitude related illness on Mount Kenya is a single case report into a military casualty who succumbed to HACE in 2012 on the Naro Moru route. This patient was suffering in silence for some days, evacuation not occurring until after setting out for the summit at 4200m on Day 4. The primary symptoms he was suffering were headache, fatigue and nausea on Day 2. However these symptoms were not reported to the expedition leader and it was not until the patient could not walk without assistance that descent finally took place (25). While we only report on AMS cases through our data collection, this case report highlights the very real risk of HACE during these short expeditions on Mt Kenya.



There are a number of potential weaknesses in our study. All of our participants were taking a variety of anti-malarials, the common side effect profiles of these medications are similar to the symptoms of AMS. The high rate of AMS in the group with a GDMO is confounded by the short length of time in country this group had, and also a possible over-reporting bias. This was observational data and collected by the participants and not by direct questioning by a medical officer or on the basis of clinical signs.

## CONCLUSION

This is the first study to report the significant incidence of AMS and severe AMS on Mount Kenya. Furthermore this AMS was associated with both a high level of perceived exertion and a short time in Kenya. These findings support the view that AT on Mount Kenya should be delayed until the end of a deployment to Kenya, and an additional day added into the expedition itinerary to allow an expanded ascent profile.

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## FIGURE LEGENDS

FIGURE 1: Representation of daily altitude gain via the Sirimon Route on Mount Kenya

FIGURE 2. Mean Lake Louise Scores throughout the duration of an ascent and descent of Mount Kenya recorded twice daily. Data are presented as the mean of all participants (error bars representing 95% confidence intervals).

FIGURE 3. Incidence of AMS in a participant cohort of 47 individuals throughout the duration of an ascent and descent of Mount Kenya recorded twice daily.

FIGURE 4. The mean Lake Louise Score recorded at two time-points (pm of day 1 and am of day 2) for participants with a high and low Borg Score.